

AN EXPERIMENTAL STUDY IN THE DESIGN OF
A SMALL DOWN-DRAFT GAS FIRED KILN

by

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A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

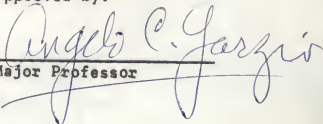
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INTRODUCTION

A kiln is the most necessary tool for the potter's studio. A variety of ceramic ware can be made with one's hands, but a kiln is necessary if the work is to be finished. The idea of a kiln is to generate heat in the most efficient and economical fashion and to transfer that heat to the ware.

Kilns date into history nearly 7,000 years.¹ Numerous variations have developed since the first kilns, which were "probably fired by simply placing pottery on the ground and building a fire around them."² Among the variations, the use of the down-draft kiln is important because of the higher temperatures which could be reached. In China, kiln firings of 2192° F or more became common in early times--as early, perhaps, as 500 B. C.³ These temperatures were made possible because of the down-draft chamber kiln which conserved and utilized the heat more effectively. A semi-continuous down-draft kiln was established in Japan nearly three hundred years ago.⁴ In North America, the down-draft kiln can be traced back to around 1875.⁵

¹Glenn C. Nelson, Ceramics, (New York: Holt, Rinehart and Winston, Inc., 1966), p. 227.

²Daniel Rhodes, Stoneware and Porcelain, (Philadelphia: Chilton Co., 1959), p. 194.

³Daniel Rhodes, Clay and Glazes for the Potter, (Philadelphia: Chilton Co., 1957), p. 58.

⁴Ruth M. Home, Ceramics for the Potter, (Peoria: Charles A. Bennett Co., Inc., 1953), p. 173.

⁵Bernard Leach, A Potter's Book, (New York: TransAtlantic Arts, Inc., 1951), pp. 185-6.

There are three ways in which heat may be transferred from ignited fuel to the ware: by conduction, convection, and radiation.

All three methods are made use of in the kiln, though the potter relies less on radiation than on conduction and the circulation of air currents. Heat is spread from one to another of the closely packed pieces from the walls of the kiln...to the wares within.⁶

The down-draft kiln is unique when compared to the up-draft kiln, in that the longer path of air currents commands a more complete use of the heat. The fire reaches the main body of the kiln in much the same manner, over a baffle wall,⁷ but does not escape through an opening at the top because the ceiling is closed. The heat must pass through the main portion of the kiln as it is being attracted by the flue in the floor. Provided the burners, air intake, and chimney are adequate, a uniform heat can be obtained by adjustments in the height of the baffle wall, the opening into the chimney, or the regulation of the damper.⁸

The purpose of this study was to design a small down-draft kiln for the learning experience and use of the writer, and to provide plans of it's construction for the benefit of other potters. Most potters know what they want in performance from a kiln, but they may lack the engineering background to design according to those wants, or they may not have the time to experiment for them.

⁶Ibid., pp. 167-8.

⁷The terms baffle wall and bag wall are used interchangeably. Glenn C. Nelson, Ceramics, (New York: Holt, Rinehart and Winston, Inc., 1966), p. 312.

⁸Ibid., pp. 230-1.

This study of a five and four-tenths cubic foot dry brick kiln is a summation of experimentation, construction procedures, and conclusions incorporating the advice and opinions of other potters and a mechanical engineer. The size of this kiln lends itself to the potter who works on a small scale or to potters who work other than full time with ceramics.

A photographic review of the finished products in clay has been supplied as an example of the results of the numerous firings which were done with different constructional variations in designing this kiln. The primary aim of this section of the thesis was to achieve a personal ideal of the aesthetic quality of the glaze and body of the pottery.

MATERIALS LIST FOR KILN CONSTRUCTION AND OPERATION

The following is a list of materials used for the kiln developed in this study:

AMOUNT	ITEM
200	2½" x 4½" x 9" K2600 Insulating Fire Bricks
132	2½" x 4½" x 9" New Fire Bricks
90	2½" x 4½" x 9" Used Fire Bricks
15	8" x 8" x 16" Cement Blocks
1	8" x 12" x 16" Cement Block
6	5/8" x 7" x 15" Kiln Shelves
4	5/8" x 15" x 15" Kiln Shelves
2	Ransome 70,000 BTU Burners
2	Hoses for Burners
2	Valves for Burners
10 lbs.	Vermiculite Insulation
1 Roll	24" x 36" Asbestos Paper
1	Galvanized Sheet Metal Unit for Chimney in Roof
6 ft.	Windmill Angle Iron
2	½" x 45" Rods
1	Pyrometer

CONSTRUCTION OF FACILITIES

Kiln Shelf Space. After considering the amount of pottery production and various kiln shelf sizes available, a horizontal kiln chamber twenty inches by twenty-seven inches was selected. To span this area, two shelf sizes were used. The first arrangement utilized three shelves which were seven by fifteen inches (Fig. 1), with one-inch spaces between each shelf and on both sides. The space in the front and back of the shelves in the kiln chamber provided space for the flow of heat currents. Three and one-half inches were allowed for the baffle wall space, and one and one-half inches for the down-draft of heat.

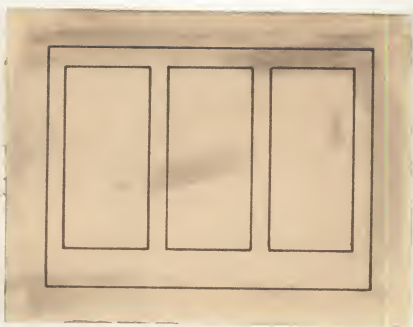


Fig. 1

Three shelves $5\frac{7}{8}$ " x 7" x 15"
in chamber 20" x 27"

The second shelf arrangement (Fig. 2) consisted of one shelf seven by fifteen inches and one shelf fifteen by fifteen inches. All spaces between the shelves and on all sides remained the same as explained for Fig. 1. These two shelf arrangements were selected, and one or the other was used as the size of the pottery to be fired demanded.

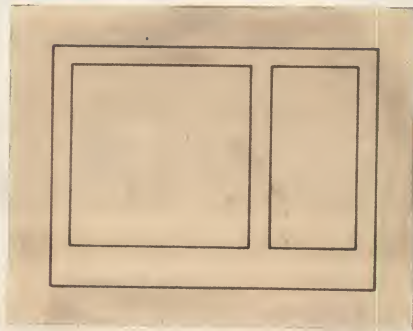


Fig. 2

Two shelves $5/8" \times 7" \times 15"$ and
 $5/8" \times 15" \times 15"$ in
 chamber $20" \times 27"$

The Foundation. Elevating the kiln to ease the kiln loading procedure was accomplished by arranging eight-inch cement blocks side by side. Consideration of shelf space, baffle wall, and kiln wall thickness totaled to a foundation dimension of forty-eight inches by forty inches by eight inches. This was accomplished by using fifteen cement blocks $8" \times 8" \times 16"$, and

one block 8" x 12" x 16" for the base of the chimney (Plate I, Fig. 3). This height also helped to protect the cement floor of the building from expansion due to conduction of heat through the kiln floor. A double strand of number nine wire was procured to encompass this course in case a problem of expansion and shifting of the base blocks occurred. However, shifting did not occur.

Insulating the Kiln Floor. Above the cement blocks, two courses⁹ of fire bricks were placed to insulate the kiln floor. The outside dimensions of the courses for the kiln chamber and walls were thirty-six inches by forty-five inches. The chimney base measured eleven inches by eighteen inches (Plate I, Fig. 4). Fire bricks were used on the first course and for the outside two rows of the second course. To better insulate the floor of the kiln, insulating bricks were used on the remaining inner rows. Three other insulating bricks were substituted for fire bricks on this second course to provide for insulation to the baffle wall which existed in the second row from the front. Each course of bricks was staggered for strength and improved insulation. Silica sand was added where needed to level low spots.

The Kiln Floor. In Design A, a solid course of insulating fire bricks lying in staggered joints completed the floor. A two and one-half inch margin was subtracted from the front side of the floor to provide for the start of a baffle wall on the front edge of the kiln (Plate II, Fig. 5).

⁹Bricklayers use the word "course" instead of "layer" to indicate rows of bricks filling in a specified area.

PLATE I



Fig. 3



Fig. 4

In Floor Design B, the top layer of the kiln floor was constructed in a design to provide for the channeling of the heat flow to the back of the kiln. These channels existed on each side and were two and one-half inches by four and one-half inches by eighteen inches. The flue was also channeled into the floor. It's dimensions were two and one-half inches by nine inches by thirty-one and one-half inches, and it was exposed to the kiln chamber in the front (Plate II, Fig. 6).

In Floor Design C, the kiln floor exposed a chimney flue and burner ports with a variation from Design B. This change included two openings on each side measuring one inch by four and one-half inches (after the kiln shelves were in place) for the purpose of directing a portion of heat to the side walls of the kiln. These openings were on the left and right side of the kiln. (Note arrows, Plate III, Fig. 7).

The Baffle Wall. Design A. In the two and one-half inch space provided in the kiln floor, a baffle wall to direct the heat up in the kiln chamber consisted of a partial wall of four insulating fire bricks thirteen and one-half inches high. Each of the insulating bricks used was one and one-fourth inch by four and one-half inches by nine inches. The bricks were split to the one and one-fourth inch thickness to conserve kiln chamber space (Plate III, Fig. 8). A fire brick was selected for the bottom course of the baffle wall for heat absorption. An eighty-degree angle brick, to ease the directional change of the flames, was selected.

PLATE II



Fig. 5



Fig. 6

PLATE III



Fig. 7



Baffle Wall Design B. With the heat channeled to the back of the kiln, the back functioned to turn the flames upward. A baffle wall, two and one-half inches from the back wall, consisting of two insulating bricks laid on their sides one above the other, formed a solid wall which continued the flame upward for nine more inches (Plate IV, Fig. 9).

Side Walls and Back. The inside cubic dimension of this kiln is seven and one-half feet, with an actual capacity for five and four-tenths cubic feet of pottery. In consideration of this size, and after consultation with Mr. Angelo Garzio, (Professor of Art at Kansas State University), a seven-inch thickness of insulation was determined to be ample to contain the heat for a cone 8 firing.

The exterior layer of brick was of fire brick and laid on edge. Fire brick was selected for two reasons: (1) it was less expensive, and (2) it was more durable.

The interior layer was of insulating fire brick lying flat. The over-all height of twenty-two and one-half inches was accomplished with five courses of exterior fire bricks on edge, and nine courses of insulating bricks lying flat to accomplish a wall width of seven inches (Plate IV, Fig. 10).

Spy Holes and Plugs. Eight spy holes were included in the structure; five on one side for specific analyzation of the kiln interior, two on the other side for general analyzation, and one leading to the flue opening. The holes were cut out of insulating

PLATE IV



Fig. 9



Fig. 10

brick of the interior wall and generally measured two and one-half inches by two inches by four and one-half inches (Plate V, Fig. 11). This two and one-half inch measurement diagonaled to two inches to provide a loosening of the spy plug at its slightest extraction and an ever-tightening wedge when inserted.

A one-fourth inch space was allowed in a corner of the layer that contained each spy hole. This allowed the plug to be extended one-half to one-fourth inch when in place for ease in grasping (Plate V, Fig. 11).

Burner Ports. To facilitate three-inch diameter burners, the two ports consisted of openings in the base of the doorway from the first course of exterior brick that stood on edge (Plate V, Fig. 12). These openings measured three and one-half inches by four and one-half inches by nine inches, which was more than ample for providing secondary air to the flame. To reduce this amount, aluminum foil was used.

The Door. This segment of the kiln was rebuilt with each firing. It consisted of the interior wall of insulation brick stacked on edge to provide a wider kiln interior space, and the exterior wall of fire brick lying flat to make the wall thickness total seven inches (Plate VI, Fig. 13). The interior layer fitted inside the inside walls, the exterior layer fitted inside the exterior walls as they joined at each front corner of the kiln, thus providing overlapping corner joints.

The Ceiling. A four-inch rising arch was used to close

PLATE V



Fig. 11



Fig. 12

the top of this unit. Two designs were used for the study.

In Ceiling Design A, four and one-half bricks cut at equal eighty-degree angles spanned the interior width of twenty-seven inches and overlapped the interior wall for a total of thirty-six inches. Each end of this arch rested on the interior side walls and was held there by a windmill leg angle iron with a one-half inch rod in the front and back. Eight rows of four and one-half bricks completed the ceiling to the top interior of the back wall and to the top interior of the door (Plate VI, Fig. 14). With only four and one-half inches of thickness to the ceiling, more light-weight insulation was needed to be consistent with other parts of the kiln. Asbestos paper (to prevent dust from the next insulation material from sifting through during expansion and contraction) was carefully cut and fitted to the top of the arch. The front row of arch brick was extended in height two and one-half more inches with scrap insulating brick, thus forming a containing wall for two and one-half to three inches of house-fill vermiculite. The side containing wall consisted of two hard one-fourth inch asbestos sheets and the back wall enclosed the vermiculite layer. This back wall was a nine inch extension of the interior back wall of the fire box (Plate VII, Fig. 15).

Ceiling Design B. (Plate VII, Fig. 16). This variation in design was a ninety degree rotation of the structure used in Design A. Since this unit was not square, the arch weight was transferred from the interior wall to the exterior wall of fire brick. Two additional rows of bricks that made up the arch were added to the arch width to span the twenty-seven inch inside

PLATE VI



Fig. 13



Fig. 14

PLATE VII



Fig. 15



Fig. 16

dimension. A side of the kiln was used to serve as a door for this change in direction of the arch, since the previously discussed front supported one side of the ceiling arch.

The Chimney. Above the bottom cement elevation block (Plate VIII, Fig. 18), two courses of fire brick corresponded to the first two courses of the kiln box. In the third course, the flue opening was extended from the kiln interior wall nine and one-half inches, and had a dimension of two and one-half inches by nine inches as it passed through the kiln back wall. This inner space of two and one-half inches by nine inches was continued beyond the exterior wall of the kiln for four and one-half inches. At this point the direction of the flue changed from horizontal to vertical (Fig. 17). From this point and up, the inside dimension of the flue gradually (within the next two

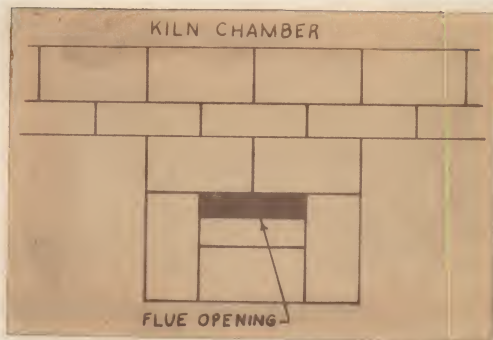


Fig. 17 Top view of flue opening and back wall of kiln

PLATE VIII

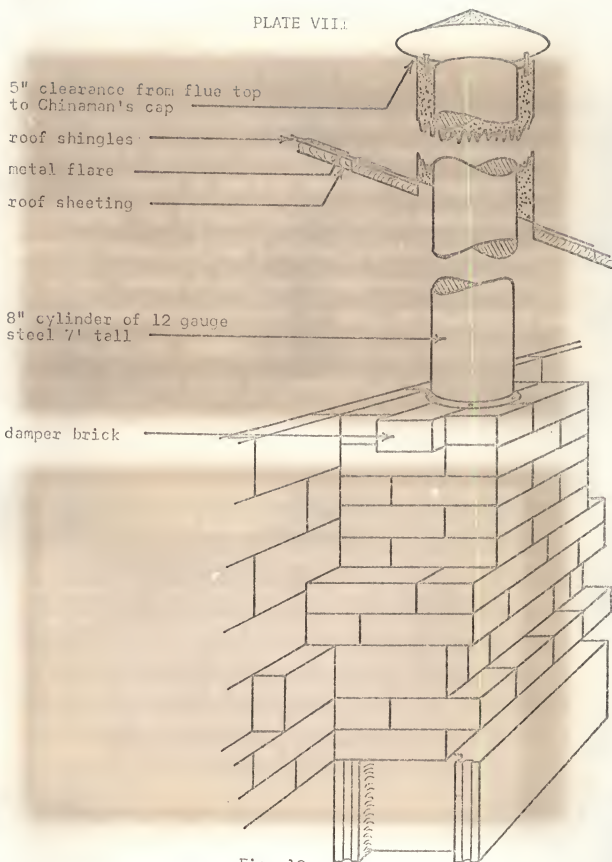


Fig. 18
The Chimney

courses) became four and one-half inches by four and one-half inches. Five more courses of fire brick on flat side helped to bring the chimney to an over-all height of thirty inches. In the top course a damper brick was located. Position of the damper was not found to be critical. It could be located in almost any course of the chimney providing that allowance is made for expansion. The maximum size of the flue opening during a successful firing was two and one-half inches by four and one-half inches. Resting on the top course was an eight-inch metallic cylinder seven feet tall made of twelve gauge steel that extended out of the building.

Kiln House. A housing unit specifically for this kiln was designed and constructed (Plate IX, Fig. 19). Outside measurements of the building were eight feet by twelve feet and six feet eight inches in height. The foundation was poured with concrete (without form boards) into a trench eighteen inches deep. The level of the house floor and foundation were the same, and was poured at the same time, without joints, and included reinforcement wire. Cement blocks constituted the major portion of the building with a wood frame, low pitch, asbestos shingle roof. Unique features of the building for the specified purpose centered around ventilation and light. The side walls had top hinged windows and hinged eaves for transmitting roof-line cool air from either direction for the entire length of the building (Plate IX, Fig. 20). A prevailing wind from either remaining direction could be augmented by the front glassed door or a

PLATE IX



Fig. 19



Fig. 20

temporarily closed two-block (sixteen inches by sixteen inches) opening on the back wall at floor level. This opening was included for a possible flue exit from the rear of the building (Plate X, Fig. 21).

Ventilating the chimney at the building roofline was accomplished with three inches of space between the eight inch chimney and a galvanized pipe fourteen inches in diameter. Plate X, Fig. 22, shows a view of this pipe from it's base as it passes through the roof of the building.

Gas line, Burners, and Firing Equipment. The gas line from a residential meter to the kiln measured forty feet. Upon recommendation of a gas company employee, one-inch pipe completed the twenty-four feet from meter to kiln house, and for the remaining distance of sixteen feet, three-fourths inch pipe was used. The building code in the city did not call for a specific depth. This line ran under a loose stone patio, and the gas company employee recommended that it be placed fifteen inches below ground level. The final length of three-fourths inch pipe included outlets for the burner hose attachments (Fig. 23).

The kiln was fired with two Ransome 70,000 BTU burners, (Plate XI, Fig. 24), and fired with natural gas at two pressures; five and one-half ounces and seven and one-half ounces of pressure in operation. Differences in results from variations of pressure are discussed later.

Controlling the amount of fuel was accomplished by a commercial valve available at a local hardware store (Plate XI,

PLATE X



Fig. 21



Fig. 22



Fig. 23

Fig. 25). A swatch of white paint on its surface and added marks of a contrasting color labeled a consistent position of #1, #2, #3, and full.

A pyrometer was used for general temperature indication on a temperature graph. The thermocouple was mounted within a spy plug by drilling a one-half inch hole in the plug. This permitted a reading to be taken from any spy hole.

Standard Orton Pyrometric Cones were used. All temperatures attempted were to 2300° F. Cones No. 2 (2124° F), No. 4 (2167° F), No. 6 (2232° F), No. 7 (2264° F), and No. 8 (2305° F), were used in most firings to trace approaching temperatures.

PLATE XI



Fig. 24



Fig. 25

FIRING PROCEDURE

Time and Temperature. All firings were subjected from two to six hours of preheating to insure dryness of pottery and kiln. This was accomplished by having one burner burning as low as the flame would allow. Time and temperature records were kept on a graph in number of hours after firing was actually started; for example, 7:30 A. M. to 8:30 A. M. was equal to hour one (Plate XII, Fig. 26).

Kiln Log. Specific mechanical information in addition to time and temperature was recorded on a Kiln Log (Plate XIII, Fig. 27). This chart provided identified space for the date, the kiln design, the firing number, the gas meter reading at the start and finish of a firing, the hour, burner valve position, damper position, atmospheric conditions of the day, and a place for additional relevant comments. A copy of the specific recordings of a firing is found on Plate XII, Fig. 26, and Plate XIII, Fig. 27. A normal firing was accomplished in ten to twelve hours consuming between ten and fourteen thousand cubic feet of natural gas.

A pyrometer was used to indicate changes that occurred when experimenting for the correct quantity of fuel, or for detecting an inaccurate supply of primary or secondary air. These readings were noted on the Kiln Log under the "Comments" column. The pyrometer proved to be a vital tool to observe almost immediately the results of a change in the fuel and oxygen ratio.

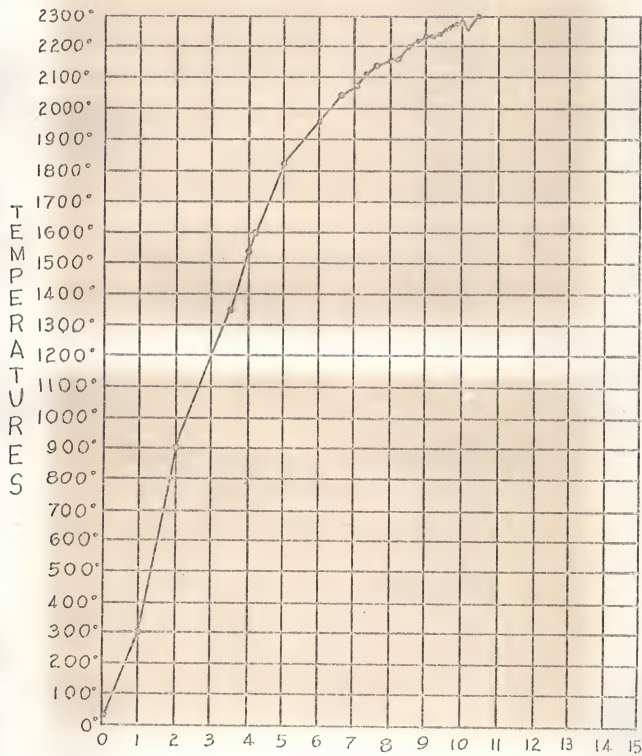
PLATE XII
FIRING TIME AND TEMPERATUREDATE March 3, 1968
KILN DESIGN # CBA
FIRING # 31

Fig. 26

PLATE XIII
KILN LOG

DAY CONDITIONS : GAS METER DATE March 3, 1968
 TEMP 100 END 7443000 KILN DESIGN # CBA
 WIND W-5 START 7431250 FIRING # 31

HOUR	DEGREES F	BURNERS	DAMPER "X 4 1/2"	COMMENTS
0	00	Both #1	2	Preheated for 2 hr. to dry kiln and pots evening prior.
1	300	2	1 1/4	Blocked all secondary air with tin foil
2	900	2	1 1/4	
3:30	1350	3	1 1/4	Dull red starting.
4	1550	3	1 1/4	
4:05	1600	3	1 1/2	Too heavy reduction, opened flue
5	1835	3	1 3/8	Much better.
6	1980	3	1 3/8	
6:40	2040	3	1 1/2	Checked bottom temp--perfect, 2040
6:45	2045	3	1 1/4	Reduce (mildly) again
6:50	2050	3	1 1/2	Oxidize again
7:05	2080	3	1 1/2	Bottom is gaining too fast
7:15	2110	3	1 1/2	Bottom still ahead 40°
7:35	2150	3	1 1/2	Cone 2 down on top; atmosphere blocks top view
8:00	2155	Full	1 3/4	Reduce more to lengthen flame to top of kiln
8:10	2160	Full	2	Back to oxidizing flame
8:30	2200	Full	2	
8:45	2220	Full	2	
9:00	2240	Full	2	Bottom temp still about 50° ahead
9:10	2240	3	1 1/2	Reduce for color and for temp on top
9:25	2240	Full	2	Cone 4 on bottom down
9:27	2245	Full	2 1/4	
9:30	2250	Full	2 1/4	
9:45	2235	Full	2 1/4	Cone 4 starting on top, cone 6 on bottom
9:50	2270	Full	2 1/4	Cone 6 starting on top
10:00	2280	3	1 1/2	Top needs to gain (estimate 15°)
10:10	2250	Full	2	Reduced too much
10:24	2300	Full	2 1/2	Full oxidation for 10 min. Kiln off. High cone 8, bottom; low cone 8, top

Fig. 27

EVALUATION OF KILN DESIGN

Kiln Floor. Floor Design A, (Plate II, Fig. 5), produced a high temperature in the front bottom of the kiln during a highly oxidizing flame. A longer, more reducing flame did bring that heat to the top front and finally across the top of the kiln chamber, but the bricks in the floor were difficult to heat to the desired temperature.

Floor Design B, (Plate II, Fig. 6), by channeling the flow of heat under the kiln floor, the absorption of heat in the bricks provided the necessary heat to vastly increase the temperature in the kiln's bottom area. There was still a tendency for excessively high temperatures near the baffle wall as it started from the floor.

Floor Design C, (Plate IV, Fig. 9), provided an even distribution of heat from front to back of the kiln floor by providing several paths for the current.

Baffle Wall. Design A, (Plate III, Fig. 8). Only the front wall of this kiln provided space for the baffle wall; thus making more usable space of the firing chamber than has been seen in many gas-fired kilns. Evaluation of Floor Design A (previously described) has been explanatory toward problems from this design in the baffle wall. Several heights of baffle walls provided to help increase temperatures in the bottom of the kiln area, but the lowest height attempted ($4\frac{1}{2}$ ") left the bottom at cone 6, the center at cone 8, and the top at cone 6. Perforating the baffle wall was an attempted experiment,

but was found to be too sensitive. A slight warpage of the baffle wall during firings (due to the intense heat on one side of the one and one-fourth inch thickness of the brick) reduced the capacity of heat being directed to the top and directed that heat to the kiln's sides. Also, the slightest misplacement of baffle wall bricks vastly changed the exact path of the flames.

Baffle Wall design B (Plate IV, Fig. 9), was successful in that it utilized radiation from the channeled heat found in kiln floor designs B and C. The height and perforation of the baffle wall was not highly critical. Differences in temperature in each corner and the center of the kiln did not occur when the height of the baffle was increased from nine inches to thirteen and one-half inches. As the flames were directed upward abruptly at the back bottom corner of the kiln, the current slowed to a lazy, flowing flame. This slow flame was clearly visible during mild to heavy reduction at red heat, and on to cone 8 temperatures as it laced toward the flue opening. Once this baffle wall was in place, it did not have to be removed to load and unload the kiln.

Ceiling Arch. No measureable difference was observed from Design A to Design B in the ceiling arch. Correspondence with several other potters produced these comments in answer to my findings about the direction of the curve and height of an arch to close the ceiling of a kiln:

From Professor Warren MacKenzie of the University of Minnesota:

I would concur [sic.] completely with your observation regarding a small kiln. However, in a larger kiln of 100 cubic feet or more, the smooth flow of the flue gases in whatever pattern is necessary for the operation of the kiln is vital. In this respect, flat roofs are out, as well as very flat arches. However, the proportion of height to width of the kiln chamber is more important as well as whether it is natural or forced draft and what kind of fuel is used.¹⁰

From Mr. Paul Soldner of the University of Iowa:

...sounds right to me...¹¹

From Mr. James Flaherty of the Archie Bray Foundation in Helena, Montana:

I feel that the arch on a kiln should not be too high as to trap the flame or too flat to break up the flame...I think the arch leads the flame in the kiln. If you're firing reduction, you want a long, slow, flame. If the flame is trapped or broken up in any way, this will have an effect on the firing, reduction and glazes.¹²

Evaluation Conclusions. Of the variations in design construction, one combination of features proved to be superior. It was referred to as Design CBA (Design C of the kiln floor, Design B of the baffle wall, and Design A of the ceiling.) The complete unit including these variations was photographed and included on Plate XIV, Fig. 28.

Awareness of physical laws observed while experimenting was the basis of establishing the purpose of this study. Several

¹⁰Warren MacKenzie, letter to writer, 8 February 1968.

¹¹Paul Soldner, letter to writer, 13 February 1968.

¹²James Flaherty, letter to writer, 12 February 1968.

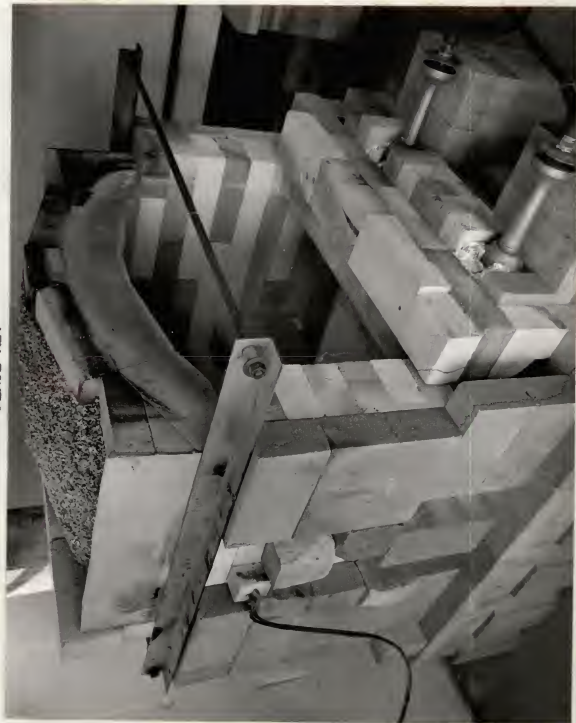


Fig. 28 Unit employing design variations: Floor (C), Baffle Wall (B), and Arch (A). Shelves covering the floor have been removed to show structure of floor.

occurrences are worthy of notice as they were important in developing a controllable unit.

During several firings, the kiln reached temperatures of 2000° to 2100° F and then seemed to completely stall. After considerable time (one to three hours) temperatures would climb at a rate of normal advance.¹³ Absorbtion of heat into the bricks of the kiln may have permitted the temperature to finally climb. After consulting with a gas company employee, it was agreed to install a meter of a larger capacity. The change proved to be fruitless. A mechanical engineer viewed the facility and concluded that the ratio of air and gas needed to be more fully explored. It was suggested to close all secondary air from the burner ports. Close observation of the Time and Temperature Chart indicated that previous firings had included an excessive amount of air that was (1) causing an improper oxygen and fuel ratio and (2) was introducing unnecessary cold air into the kiln chamber. After the amount of secondary air was reduced, the "stall" no longer existed. With a faster firing time there was less fuel consumed.

During initial firings, pottery in the bottom shelf of the kiln was placed directly on kiln shelves that covered the channeled kiln floor. Thus, these pieces were quickly exposed to conduction of heat from the intensely hot burner channels in the early stages of the firing. As a result of this direct conduction of heat, the pottery on the bottom shelf reached maturing temp-

¹³Based on "Typical Heating Schedules", Clay and Glazes for the Potter, by Daniel Rhodes, p. 201.

ature much too soon. Additional shelves placed three-fourths inch above the shelves used to enclose the chamber eliminated the direct conduction of heat to the pottery. The elevation was accomplished with the use of pieces of a broken kiln shelf.

Only one bisque firing has been performed in this unit. An oxydizing atmosphere was achieved for the firing by setting the damper at two and one-half inches for the entire cycle, secondary air was completely off and a regular burner adjustment as used in a glaze firing was used. Cones were not used as the color indicated a temperature of 1700--1800° F. This temperature was achieved in six hours with a two hour pre-heating time. With only one burner on as low as would burn for the pre-heating phase of the firing, alternations of positions were made from one port to the other for uniformity within the kiln. Including the bisque firing, a total of thirty-six firings were attempted thus far.

Analysis of verbal comments from other potters recommend a larger kiln for gas-fired operations. It is agreed that a larger unit may perform the objective task of uniformity and atmospheric conditions toward more perfection. The established purpose of this study was to provide a modest size unit for a potter on a limited time schedule for pottery.

EVALUATION OF THESIS POTTERY

Twenty pieces of pottery were selected from the firings during this study. An attempt has been made to include a variety of sizes, designs and colors to present the goal of this potter--a quality ware justifying the need for a quality kiln.

This study has an emphasis toward the facility of a kiln, but it should be understood that the underlying ultimate efforts are toward aesthetic endeavors. Total agreement is in accord with Paul Soldner: "Control alone of a kiln is not enough. The hardest thing is still getting beyond technical knowledge..."¹⁴

All clay bodies of this pottery were of seventy-five percent Pittsburg clay of Pittsburg, Kansas, and twenty-five percent native earthenware clay from the Tuttle Creek Lake area near Manhattan, Kansas. The glaze was a soda feldspar glaze with a maturity range from cone 5 to cone 9.

¹⁴Paul Soldner, letter to writer, 13 February 1968.

EXPLANATION OF PLATE XV

This form is accented by variations of glaze color. Iron oxide brushed over wax resist varies the color from a cool white to shades of gray and finally a warm, dark color (9" wide).

PLATE XV



Fig. 29

EXPLANATION OF PLATE XVI

This closed form is terminated with a lid knob. An iron red glaze has been used with circular trails of opaque white accents ($8\frac{1}{2}$ " tall).

PLATE XVI



Fig. 30

EXPLANATION OF PLATE XVII

This bowl form makes use of the casual handling of wax resist and iron oxide brush design.

PLATE XVII



Fig. 31

EXPLANATION OF PLATE XVIII

Geometric decoration and form are accented
with a small lid handle ($6\frac{1}{2}$ " tall).

PLATE XVIII



Fig. 32

EXPLANATION OF PLATE XIX

The double circles of this decoration relieve
the quietness of the surrounding negative areas
(9" wide).

PLATE XIX



Fig. 33

EXPLANATION OF PLATE XX

The method of glazing this form is a direct relationship to the feel of the body's course texture. Spattered streams of iron oxide form a linear pattern across the open slab (7" x 8" wide).

PLATE XX



Fig. 34

EXPLANATION OF PLATE XXI

A repeated design pattern of light greens
and browns supply the accent on the extreme edges
of this bowl. (12" in diameter)

PLATE XXI



Fig. 35

EXPLANATION OF PLATE XXII

A wall hanging depicting three birds in a combination of deep texture and smooth surface (5" x 10" dimension).

PLATE XXII



Fig. 36

EXPLANATION OF PLATE XXIII

The interior of this bowl received numerous coatings of stonized iron and chromium oxides. Separate coatings of oxides were applied alternately over scraps of paper in varied positions (15" in diameter).

PLATE XXIII



Fig. 37

EXPLANATION OF PLATE XXIV

Left. Shown is an example of a low vase having dominant horizontal lines in it's form (5½" tall).

Center. A bottle with variations from copper red to a light neutral color (8" tall).

Right back. Ash tray form accented with brush strokes of black copper oxides against a white interior glaze (6" wide).

Right front. Ash tray of exposed bare clay complimented by a simple interior surface and color. Finish nails accent the character (5" wide).

PLATE XXIV



Fig. 38

EXPLANATION OF PLATE XXV

Examples of several elements of a tea set.

Six cups, cream and sugar containers, a serving plate and a teapot complete the set which has a greenish-brown glaze. Teapot is 8" tall including handle.

PLATE XXV



Fig. 39

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AN EXPERIMENTAL STUDY IN THE DESIGN OF
A SMALL DOWN-DRAFT GAS FIRED KILN

by

MAURICE WINSTON BERGGREN

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ABSTRACT

The purpose of this study was an attempt to develop a controllable, even firing, small kiln, capable of stoneware temperatures.

The contents included references to other kiln designs, both in the past and present time, personal correspondence with other potters, advice from a mechanical engineering consultant, and personal experiences gained during the study.

A five and four-tenths cubic foot down-draft natural gas fired kiln was constructed using a combination of dry insulating and fire bricks. Seven variations in design were developed and employed for evaluation. Separate kiln logs and time and temperature charts were used for each firing to record results from variations in the kiln design. Stages of construction were photographed or illustrated to portray a pictorial development of the unit. Firing records from a typical firing were included to show operational procedures.

A combination of features from several experimental kiln designs fulfilled the established goals of the study. Specifically, this design channeled the path of the flame under the floor of the kiln to the kiln's bottom back; upward at the back wall, across the kiln top and downward to the flue opening. Again the direction of the flow of heat was channeled under the kiln floor toward the back of the kiln and finally through the chimney. Kiln Floor Design C, Baffle Wall Design B, and Ceiling

Design A were used in combination to fulfill the above kiln design.

Firing time for this kiln to reach cone 8 (2305° F), ranged between ten and twelve hours. This factor was variable in regard to the amount of reduction desired and the amount of experimenting with fuel and oxygen in order to gain knowledge in producing specific control of the kiln.